Functional Measurement Requirements

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These requirements list a broad range of measurement capabilities, some of which will be implemented in the first year of development and some which will be implemented as the system continues to develop and expand.

1. Pulsed emitter spectra and time-waveform characteristics
    a. Single pulse shapes: measurement of the time domain pulse envelope, pulse width, rise and fall times. (**Priority I**)
        i. Time domain pulse envelope detection
        ii. Digitization with appropriate processing
    b. Separation of multiple emitters (**Priority II**)
        i. Pulse sorting (interval, width, modulation): distinguishing different emitters by examining pulse spacing patterns, pulse width, and/or modulation type
        ii. Beam scanning envelopes: distinguishing different emitters by de-interleaving time-of-arrival and amplitude of main beams
    c. Spectra: measurements to determine peak and average power in a bandwidth over a frequency span (**Priority I**)
        i. Stepped measurement: Measurement in which the instrument provides power information within a bandwidth at a single frequency setting as the instrument is stepped across a band, where peak power information is recorded over at least one hit of the main lobe of the emitter. This procedure accommodates wide dynamic range requirements by allowing adjustment of the front-end attenuation between frequency steps.
        ii. Swept measurement: measurement which the instrument provides power vs. frequency information across a span between triggered sweeps.
        iii. Digitized pulse(s) with appropriate processing to determine spectral characteristics.
    d. PRF sequence: measurements to determine the pulse spacing characteristic as a function of time (inc. stagger, dither, etc.) with possible processing to provide statistical information. (**Priority I**)
        i. Digitized pulse sequence with appropriate processing to determine PRF sequence
        ii. Measurements using an instrument dedicated to determining time intervals between pulses to extract PRF sequence information
    e. Air Traffic Control Radar Beacon System (ATCRBS) measurements to determine patterns of the omni and directional antennas used in this system. (**Priority III** - possible solution is to rent LeCroy scope, and extract from RFIMS software.)
    f. Modulation analysis: measurements to characterize frequency and phase changes within the pulse (**Priority II**)
        i. Digitized pulse sequence with appropriate processing to determine frequency and phase changes of the carrier signal
        ii. Measurements using an instrument dedicated to determining frequency and phase changes
    g. Antenna patterns: these measurements determine the antenna pattern of a pulse

emitter by determining the signal power at various azimuth angles of beam direction with an single elevation cut. Statistical analysis of the antenna pattern can be included (example: probability statistics in azimuth sectors). (**Priority I**)

i. Time domain pulse envelope detection
ii. Digitization with appropriate processing

h. Correlation of signal characteristics with frequency allocation database (**Priority III**)

i. Demodulation to recover audio where appropriate (**Priority III**)

2. Non-pulsed individual emitters

a. Time-domain waveform: acquisition of emitter waveform as amplitude (or power) vs. time for the purpose of examining the waveform shape and/or computing statistical metrics. (**Priority I**)

i. Time domain envelope detection
ii. Digitization with appropriate processing

b. Spectra: measurements to determine peak and average power in a bandwidth over a frequency span (**Priority I**)

i. Stepped measurement: Measurement in which the instrument provides power information within a bandwidth at a single frequency setting as the instrument is stepped across a band, where peak (average, other statistical metrics) power level is recorded. This procedure accommodates wide dynamic range requirements by allowing adjustment of the front-end attenuation between frequency steps.
ii. Swept measurement: measurement which the instrument provides power vs. frequency information across a span between triggered sweeps (could be an M3 measurement within a single channel - see section7ai).
iii. Digitized waveform with appropriate processing to determine spectral characteristics.

c. Modulation characterization: measurements to characterize frequency, amplitude, and phase changes of non-pulsed signals for purpose of identification and/or quantifying various metrics. (**Priority I**)

i. Digitization with appropriate processing
ii. Modulation analysis instrumentation

d. Separation of multiple emitters using correlation, demodulation, or other techniques (**Priority III**)

e. Correlation of signal characteristics with frequency allocation database (**Priority III**)

f. Antenna patterns: these measurements determine the antenna pattern of an emitter by determining the signal power at various azimuth angles of the antenna. Statistical analysis of the antenna pattern can be included. (**Priority III**)

g. Demodulation to recover audio where appropriate (**Priority III**)

3. Measurements to determine receiver characteristics (**Priority II**)

a. IF characteristics - i.e., measure the transfer function at the IF section of the receiver.

b. Receiver selectivity for an interfering source offset at specified) f from the tuned frequency of the receiver.

c. Measure interfering signal time-domain waveform response in a victim receiver IF output at specified) f from the tuned frequency of the receiver.
d. RF/RF+IF Sensitivity, dynamic range, bit error rates, compression point, etc.

4. Multiple bandwidth receiver responses: measurements to determine various signal characteristics as a function of received bandwidth (**Priority I**)
   a. Time domain envelope detection
   b. Digitization with appropriate processing
5. Absolute field strength: measurements to determine the absolute field strength as a function of distance and/or position for a frequencies span (**Priority I**)
6. Direction finding: measurements to determine the direction of an emitter
   a. Single azimuth on pulsed emitters(gated and non-gated) (**Priority II**)
      i. Time domain envelope detection
      ii. Digitization with appropriate processing
      iii. COTS dedicated direction finding
   b. Single azimuth on non-pulsed emitters (gated and non-gated) (**Priority II**)
      i. Time domain envelope detection
      ii. Digitization with appropriate processing
      iii. COTS dedicated direction finding (**Exception - Priority I** - for < 1 GHz)
   c. Active tracking of pulsed and non-pulsed emitters in both azimuth and elevation. (**Priority III**)
   d. Finding specific location of and emitter (pulsed or non-pulse) (**Priority III**)
      i. Triangulation techniques
      ii. Path time-of-travel with direction
7. Spectrum occupancy and usage: measurements to determine whether (and how often) transmissions (and/or communications) exist within specified frequencies of the spectrum (frequency, time, and/or code space); should be capable of sequentially tuning at a user defined set of frequencies (non-uniformly or uniformly spaced) and changing the bandwidth, sensitivity, and other instrument controls (or ways of processing) at each frequency, tailored to the the specific emissions in each channel.
   a. Band-dependent and -independent broadband spectrum survey series: Band-dependent measurements are constrained to specific frequency allocations. Band-independent measurements are performed without consideration for any frequency allocations
      i. Swept M3 - sample/peak detector (**Priority I**)
         (1) Frequency vs. Time using an analog sweep - data downloaded after each sweep and analyzed on computer
         (2) Digitized IF of specific bandwidth combined with post processing.
      ii. Stepped M3 - peak detector (**Priority I**)
         (1) Maximum, mean, and minimum statistics of multiple maximums, each maximum determined during one gated period (eg. one beam rotation) at multiple narrow bandwidths
            (a) Time domain envelope detection
            (b) Digitization with appropriate processing
         (2) Digitized with wide bandwidth, triggered at the gated-on time. Multiple acquisitions used to determine maximum, mean, and minimum statistics of maximum power during one gated period.

iii. Measurement to build distributions within a specified bandwidth (e.g,. APDs, modulation domain distributions): (**Priority I**)
(1) Amplitude, frequency, and/or phase over time using an analog sweep to build distributions at a specified center frequency
(a) determine within instrument
(b) determined outside instrument
(2) Digitized IF of specific bandwidth combined with post processing to develop distributions of amplitude, frequency, and/or phase.

iv. Percentile vs. channel measurements: measurements to determine the percentage of time a signal is present within a channel. (**Priority I**)
(1) Direct channel signal measurements
(2) Statistics derived from control channel information

v. Percentile vs. code space measurements: measurements to determine a distribution of code space occupancy within a channel. (**Priority III**)
(1) Direct channel signal measurements
(2) Statistics derived from control channel information

vi. Azimuth dish scans: spectrum occupancy measurements performed using a directional (high gain) antenna (vertical and horizontal polarizations) with scans though a range of azimuths. Spectrum occupancy is built from a compilation of multiple azimuth positions. The purpose is to provide a higher sensitivity survey - as opposed to the use of an omni directional antenna. (**Priority II**)

b. Correlation of occupancy and usages with frequency allocation database (**Priority III**)

c. Measurements to determine statistics of lengths of messages (**Priority II**)

d. Modulation analysis: measurements to characterize amplitude, frequency and phase changes to determine modulation and frequency of occurrence (**Priority II**)
i. Digitized pulse sequence with appropriate processing to determine frequency and phase changes of the carrier signal
ii. Measurements using an instrument dedicated to determining frequency and phase changes

e. Satellite Measurements: Measurements to determine occupancy and usage on satellite transponders. (**Priority III**)

f. Simultaneous peak/average measurements to rapidly identify pulsed signals. (**Priority III**)

8. Interference detection

a. Undesired signal detection with alarms: Spectrum and/or direction scans in which interference sources are detected, along with an indication that the detection has occurred. Data recording (i.e., for signal identification) may be instigated by the indicator. (**Priority I/II**)

b. Spectrograph: measurements to record amplitude vs. frequency vs. time (**Priority I**)
i. Time domain envelope detection
ii. Digitization with appropriate processing

c. Simultaneous peak/average measurements to rapidly identify pulsed signals. (**Priority III**)

d. Identify the interference coupling mechanism through receiver section-by-section

measurements. (**Priority III**)

9. Simulation of known emitter (desired and/or undesired) to measure system performance and/or compatibility.
    a. Record-playback: Record an actual emitter and playback the recorded signal. (**Priority I**)
    b. Reconstruction of an emitter's signal using the known characteristics of the signal (including antenna pattern, and/or propagation characteristics) (**Priority I/II**)
        i. Hardware signal reconstruction
        ii. Software signal and receiver simulation
    c. Reconstruction of a reflected radar emission with multiple radar targets (**Priority III**)
        i. Hardware signal reconstruction
        ii. Software signal and receiver simulation
10. Radio noise (apparent random process that can only be described through statistical analysis) (**Priority II**)
    a. Measurements to acquire data for statistical analysis (amplitude detection, digitization, zero crossing detection, etc.)
    b. Statistical processing of noise measurements data (APDs, zero crossings, etc.)
    c. Source identification
        i. Location finding: measuring signal amplitude vs. azimuth or coordinate location.
        ii. Correlation of statistical characteristics of measured noise with known noise sources.
11. Propagation (**Priority II**)
    a. Propagation path statistics: amplitude, phase, and frequency measurement of a received signal vs. time at a fixed location.
    b. Channel characteristic statistics: amplitude, phase and frequency measurements of a received signal over a physical area to determine channel propagation statistics.
    c. Coverage: amplitude vs. variable coordinate location.